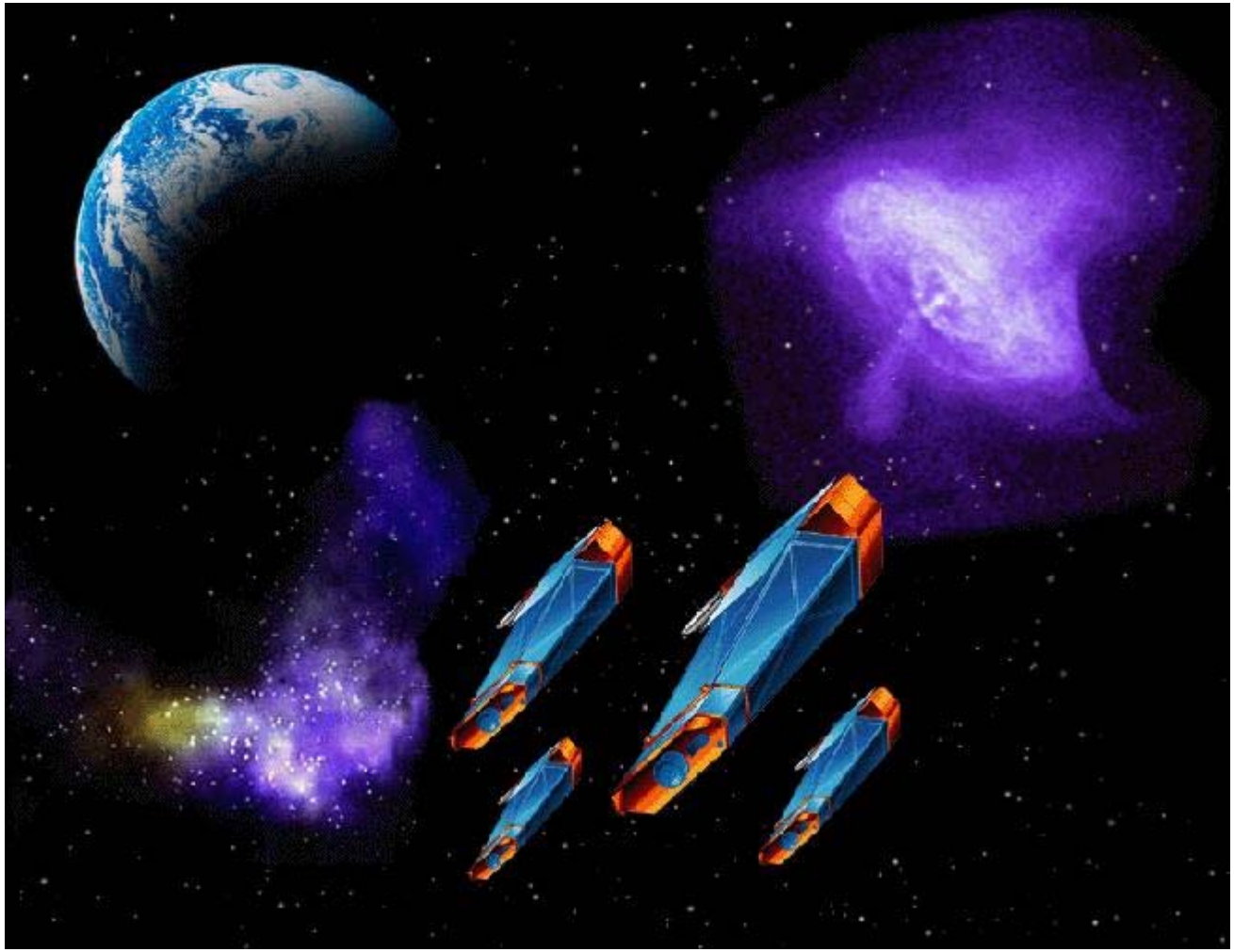
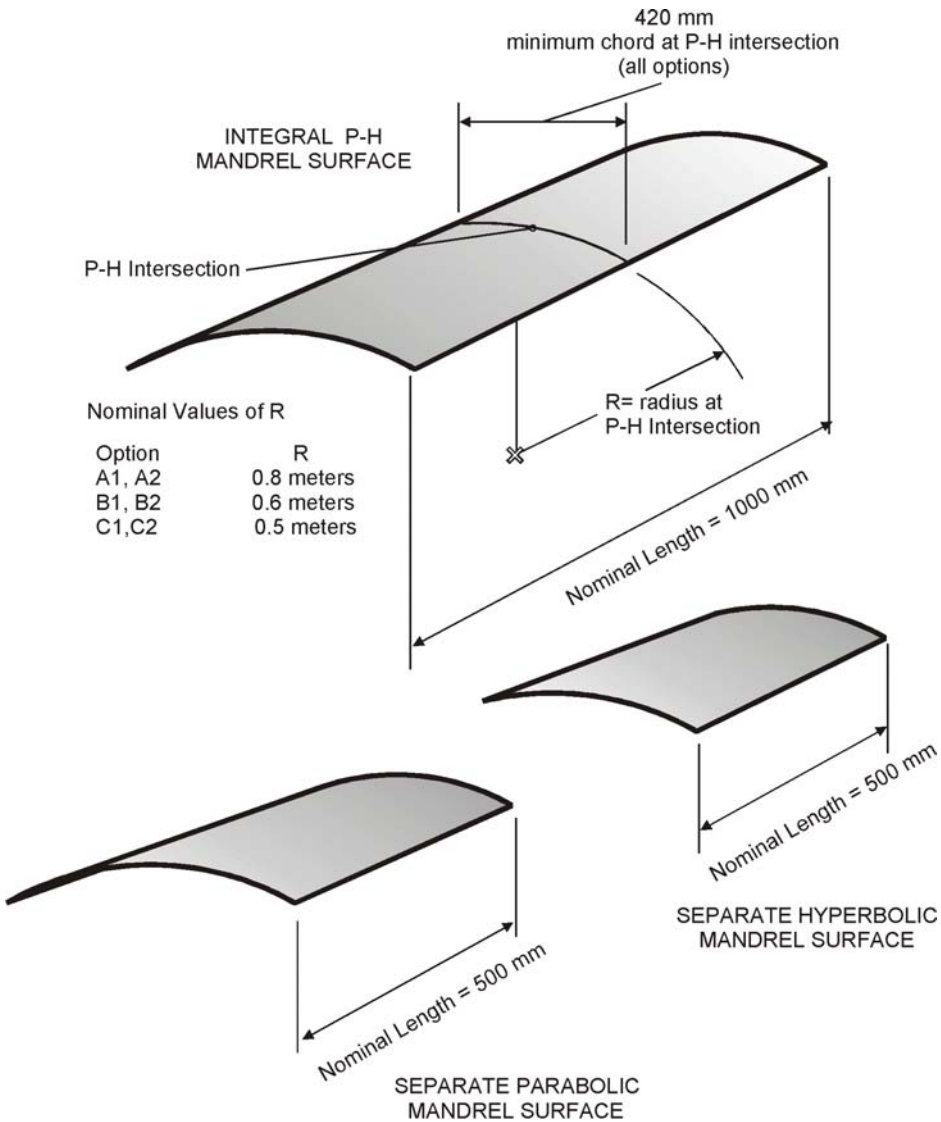
X-ray Optics Development at MSFC



Steve O'Dell

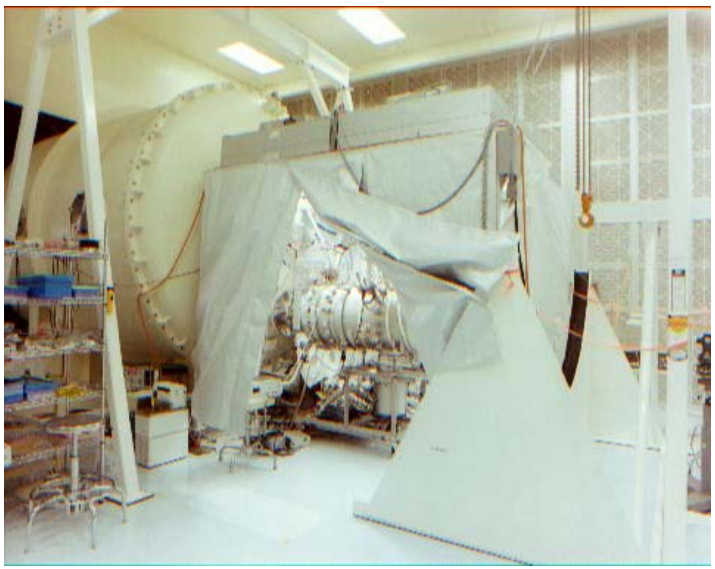
NASA Marshall Space Flight Center

Precision mandrels



- **Full-cylinder metal mandrels**
  - D = 0.25 m, L = 0.20 m, F = 3.9 m
    - Fabricated at MSFC (1998 Jun) $HPD_{geom} \approx 26''$
  - D = 0.50 m, L = 0.60 m, F = 8.4 m
    - Fabricated at MSFC (1999 Apr) $HPD_{geom} \approx 10''$
    - Received 2 from Zeiss (1999 Aug) $HPD_{geom} \approx 5''$
  - Potential use for smaller segments
    - Glass-coated for epoxy replication
    - Possible cost and time savings
- **Segment glassy-ceramic mandrels**
  - D = 1.6 m (30°), L = 1.0 m, F = 10.0 m
    - Being procured now $HPD_{geom} < 4''$
  - D = 1.2 m (30°), L = 1.0 m, F = 10.0 m
    - To be procured as option
  - D = 1.0 m (30°), L = 1.0 m, F = 10.0 m
    - To be procured as option

X-ray testing



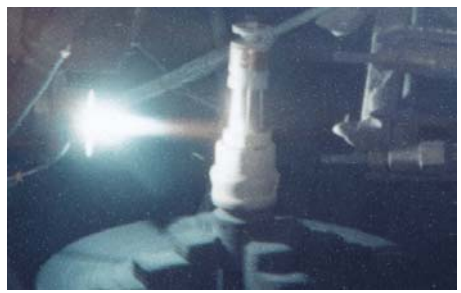
- **Facilities for testing 10-m focal-length optics**
  - 100-m “Stray-Light Facility”
  - 530-m X-ray Calibration Facility (XRCF)

Other support for epoxy replication

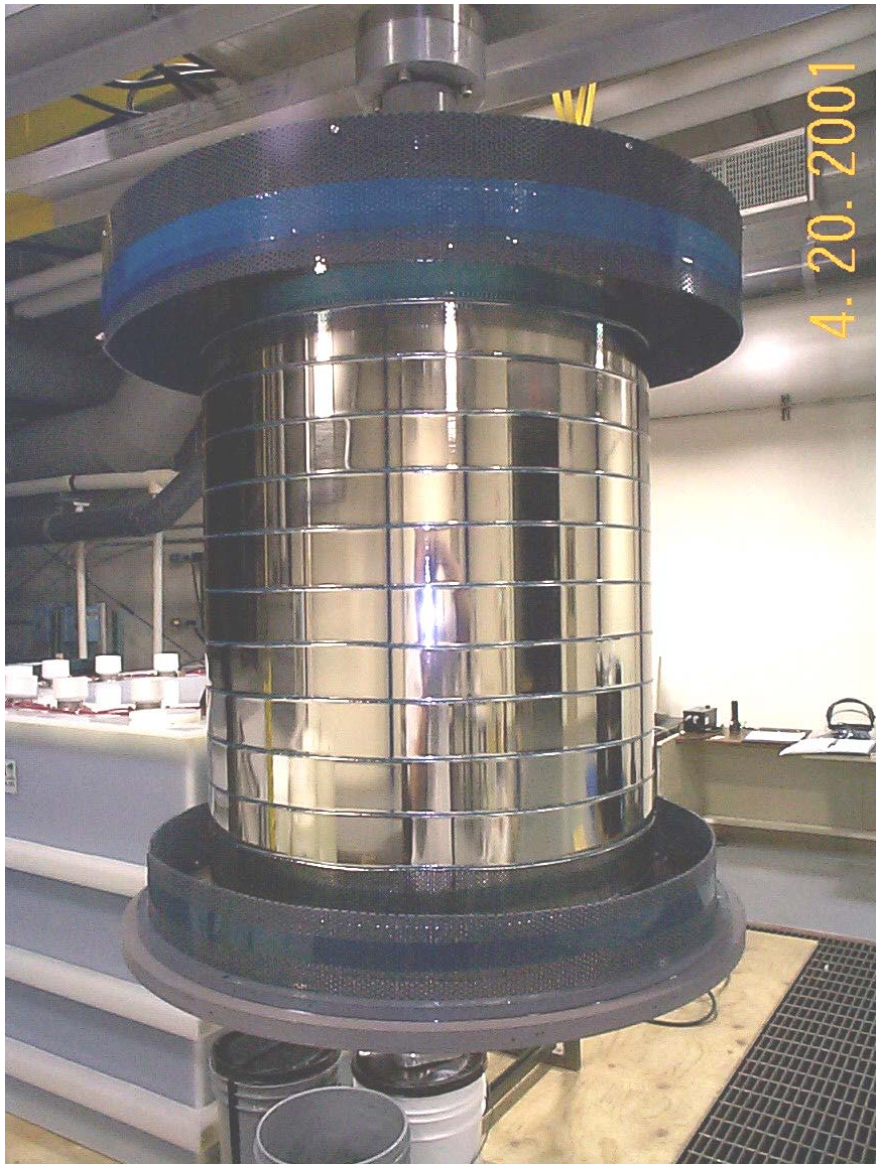
- **Near-term support activities**
  - Cleaning and coating large mandrels
    - Epoxy stripping of metal mandrels
  - Scaling-up of epoxy-replication process
    - Assist GSFC with 50-cm optics
    - Vacuum housing fabrication
    - Mandrel heating strips for curing
  - Metrology of large mandrels & mirrors
- **Long-term MSFC role undecided**

Plasma-sprayed carriers

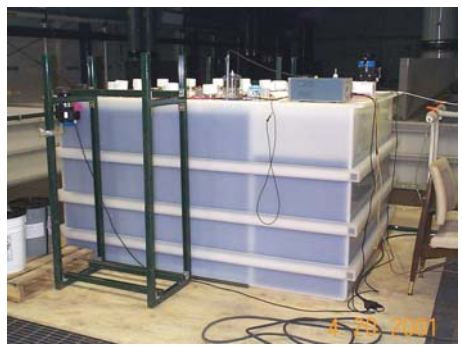
- **Plasma Processes, Inc. (Huntsville)**
  - SBIR-2 under GSFC
    - MSFC support to SBIR-2 research
    - Plasma-sprayed Vanasil alloy (2.7 specific density)
  - Status
    - Refined powder-injection method
    - Are releasing more successfully
    - Sprayed on 50-cm-diameter rings and mandrel
    - Are obtaining high stress gradients in deposits
    - Continue to refine spray parameters



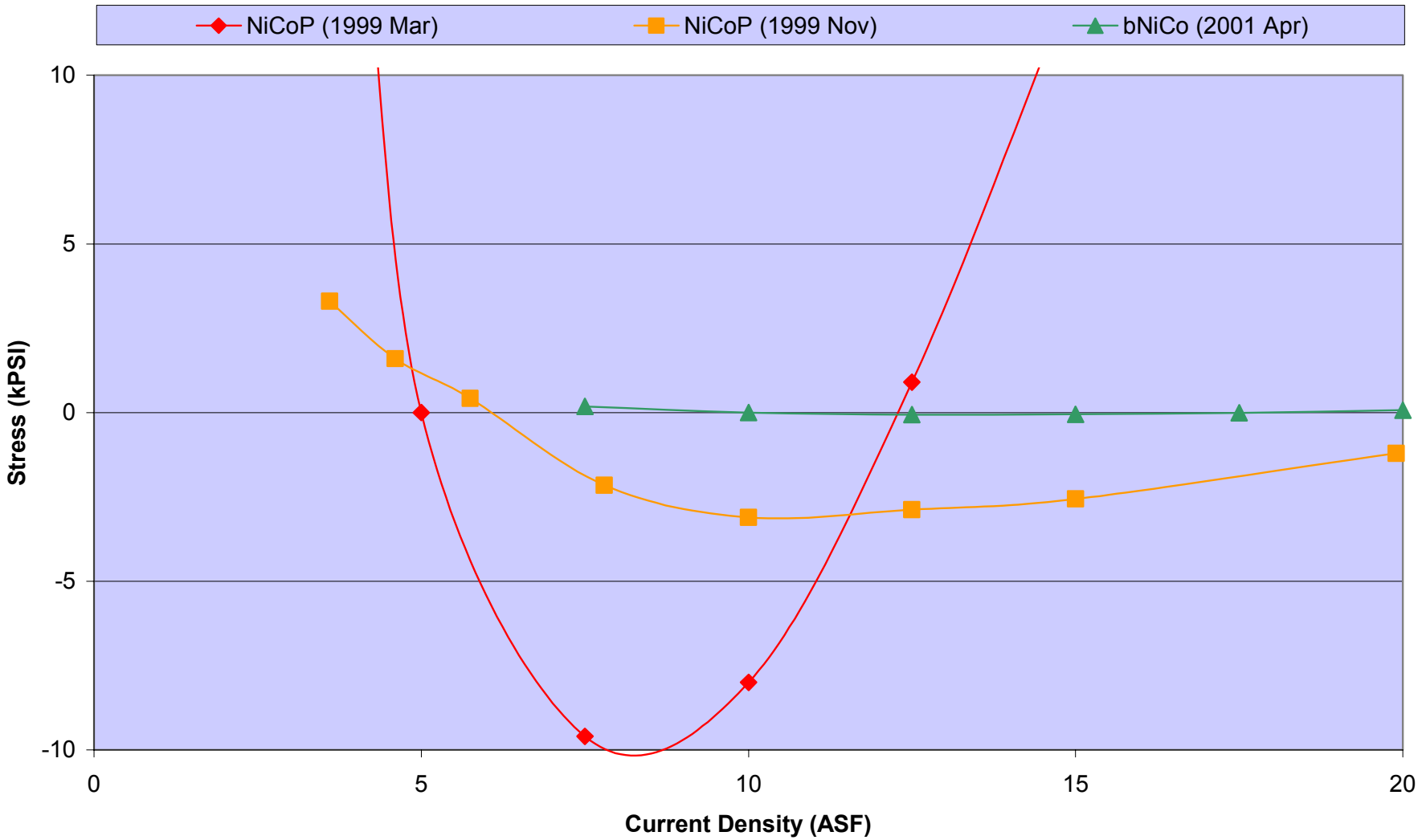
Electroformed-nickel optics



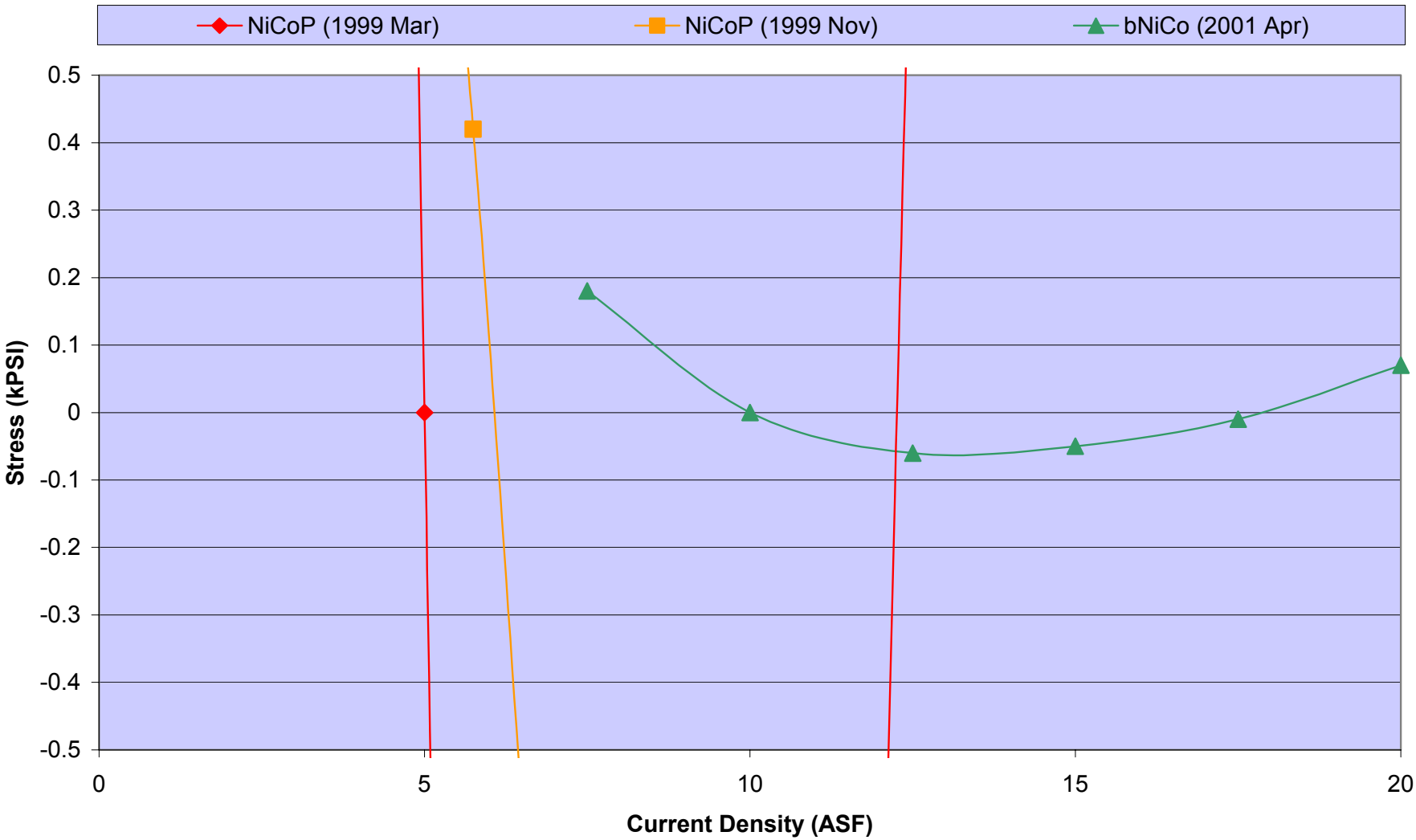
- **Programmatic status**
  - No longer funded by Constellation X
  - Funded by SR&T and CETDP
- **Technical status**
  - Suspended work on NiCoP alloy
    - Insufficient resources for dual study
    - Stress control remained problematic
    - Other possible problems with alloy
  - Are progressing well with bNiCo alloy
    - Very-low stress and stress sensitivity
    - Sufficient microstrength
  - Are finding heat treatment beneficial
  - Will electroform first bNiCo 0.5-m optic



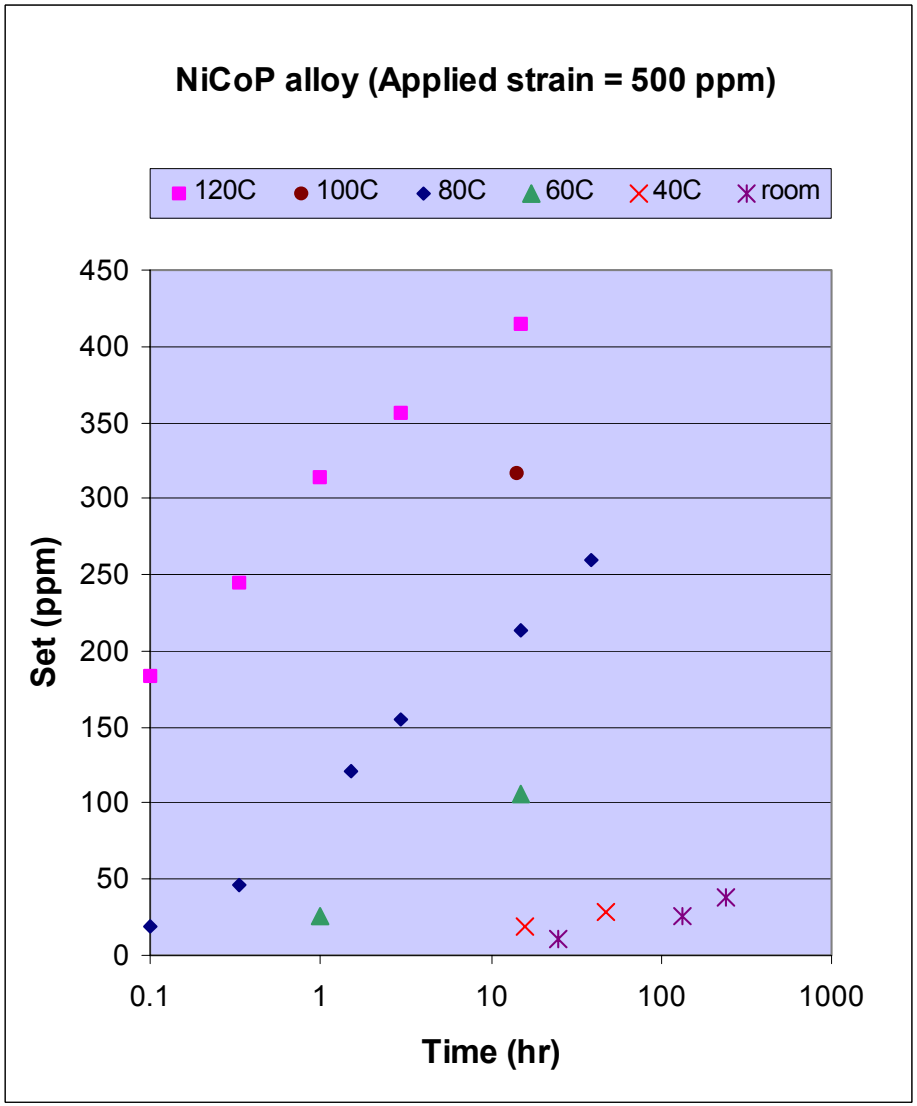
Plating-stress sensitivity



Plating-stress sensitivity

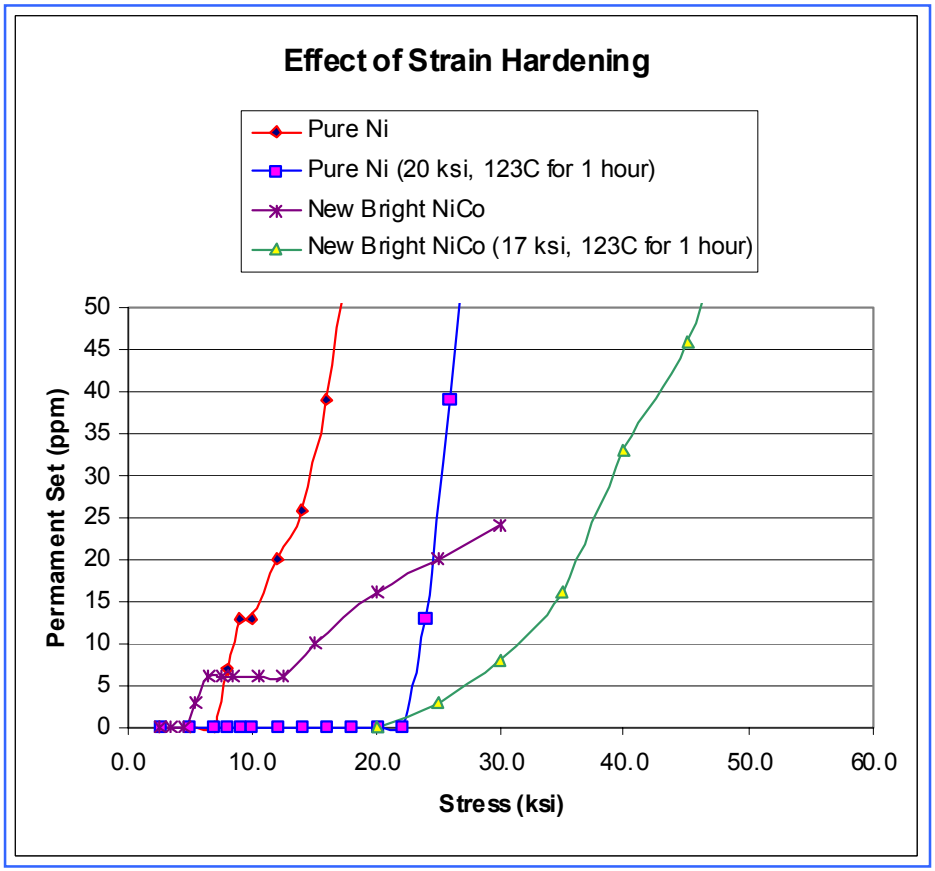


Heat-treatment effects



- **Heat-treatment process**
  - Recently began study of this process
  - Heat (Ni-alloy) shell on (Al) mandrel
  - Differing CTEs stretches nickel
- **Three effects of this heat treatment**
  - Thermosetting
    - Removes some strain from residual stress with permanent set
  - Strain hardening
    - Increases microyield strength to stress experienced
  - Stress relief
    - Promotes relaxation of internal stresses
    - Relaxation evident in 0.5-m optics
- **Must study for negative effects**
  - Need stability for expected conditions
  - Blistering of NiCoP alloy

Heat-treatment effects



- 50M1S5 (flight-weight NiCoP shell)
  - HPD_{geom} = 38″ (initial) → 17″ (after year)
- 50M1S7 (2 x flight-weight NiCoP shell)
  - HPD_{geom} = 75″ (initial) → 15″ (heat treat)

- **Heat-treatment process**
  - Recently began study of this process
  - Heat (Ni-alloy) shell on (Al) mandrel
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- **Three effects of this heat treatment**
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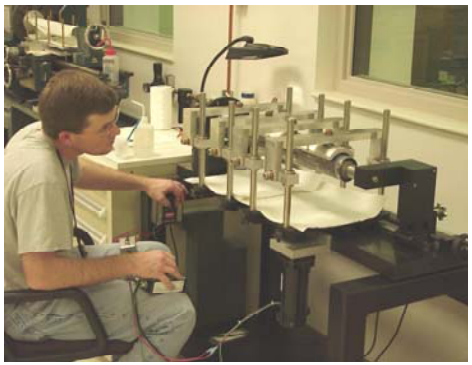
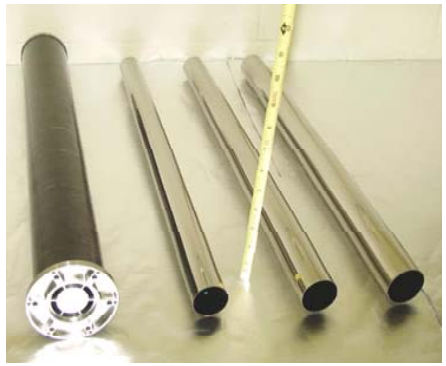
High-Energy Replicated Optics





- **HERO bNiCo optics**
  - DU: 2 3-shell modules, F = 3 m
    - HPD_{shell} = 30″ (30 keV, measured)
    - HPD_{system} = 45″ (30 keV, measured)
  - FU: 16 15-shell modules, F = 6 m
    - HPD_{shell} = 10″ (goal)
    - HPD_{system} = 15″ (goal)
- **HERO mandrels**
  - 30″ mandrels commercially ground
  - 10″ mandrels commercially D-turned
  - All polished at MSFC